

ROAD (Remote Observatory Atacama Desert): Intensive Observations of Variable Stars

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Abstract

The author discusses his new remote observatory under pristine skies and the intensive observations of variable stars he is accomplishing. The stars under investigation are mainly cataclysmic variables, observed in response to AAVSO, CBA, and VSNET alerts; other types, such as RR Lyrae stars, were also observed. Examples are presented of dense observations of different cataclysmic variables as well as an RR Lyrae star. Featured is the first bright outburst of SV Ari (Nova Ari 1905) since its discovery, as well as the first outburst of UGWZ candidate BW Scl. Results for VW Hyi, another cataclysmic variable, will also be shown. Furthermore, an intensively observed RR Lyrae star will be highlighted.

1. Introduction

It is an amateur astronomer's dream to observe under pristine dark and clear skies nearly every night like at the sites where the professional astronomical observatories are located. Such a dream normally never comes true. However, modern techniques and infrastructures in most countries make it possible nowadays to observe from remote sites using off-the-shelf technology. The author installed a remote observatory under the dark skies of the Atacama Desert close to the town of San Pedro de Atacama, Chile. The telescope is housed at SPACE (San Pedro de Atacama Celestial Exploration (<http://www.spaceobs.com/index.html>)). The owner, also an amateur astronomer, formerly worked at the European Southern Observatory (ESO) at the big telescope sites in Chile. In 2003 he started SPACE, which has been extended to telescope hosting for the last couple of years. I contacted him in 2009 and decided to establish my observatory at his place.

Unfortunately, delivery of the telescope took much longer than anticipated, and only in July 2011 was I able to install the dome, mount, and telescope. Since August 1, 2011, the remote observatory has been producing data every clear night. So far, in less than 8.5 months of operation, this amounted to about 220 data-taking nights. Not bad, is it not?

I am collaborating on the observation of cataclysmic variable stars with J. Patterson of the Center for Backyard Astrophysics (CBA) and T. Kato of the VSNET email alerts. Since I am also interested in observing RR Lyrae stars, I collaborate with the Groupe Européen d'Observations Stellaires (GEOS). In Belgium, I am a member of the Werkgroep Veranderlijke Sterren (WVS) on High Amplitude Delta Scuti (HADS) stars. I am also member of the AAVSO and the German Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne (BAV).

During the many clear nights I gather a lot of data on many stars. Since space here is limited, I restrict myself to some highlights: the outbursts of SV Ari, BW Scl, and VW Hyi; and I also look at an RR Lyrae-type star with a strong Blazhko effect.

2. Observatory

The remote observatory in Chile houses a 40-cm $f/6.8$ Optimized Dall-Kirkham (ODK) from Orion Optics, England. The CCD camera is from Finger Lakes Instruments (FLI) and contains a Kodak 16803 CCD chip with $4k \times 4k$ pixels of $9 \mu\text{m}$ size. The filter wheel is also from FLI and contains photometric BVI filters from Astrodon.

Figure 1 shows an image of the remote telescope in Chile. It is housed in a clamshell dome, making easy movement of the telescope possible without the need to follow with a shutter of a normal dome. Images of a night's session are either acquired with ACP or CCDCOMMANDER automation software. Further analysis in terms of determination of the brightness of the stars is done using a program developed by P. de Ponthierre (2010). The data are then finally submitted to the AAVSO.

3. SV Arietis (Nova Arietis 1905)

As a first example, I show the results of the campaign on SV Arietis (Nova Ari 1905). SV Ari was discovered on November 6, 1905, by M. and G. Wolf (1905) in Heidelberg, Germany, at a photographic magnitude of 12.0. It was reported that it had brightened from magnitude 22.1. Himpel and Jantsch (1943) reported a possible sighting in September 1943, at a magnitude of 15.7, but this was not confirmed. No brightness increase has been observed for this star ever since.

Then, on 2011 August 2.788 UT, R. Stubbings observed the field of SV Ari and saw an object at magnitude 15.0. He sent an alert via the mailing list cvnet-outburst to ask for confirmation. The outburst information was also given via the VSNET mailing list. This led to the confirmation by G. Masi (2011) and R. Fidrich (2011). I saw those alerts via VSNET, and since G. Masi immediately took a time series and observed superhumps, I also decided to go after this star

and started a time series at August 2.844 UT, just 1.34 hours after the initial discovery. A first analysis of the data of G. Masi by the Kyoto team (Ohshima *et al.* 2011) showed that the star is probably an SU UMa type dwarf nova with a superhump period of about 1.54 hours. The present outburst seems also not as bright as the one during the discovery of magnitude 12. However, another mail from T. Kato (2011a) on VSNET reported that probably the original brightness estimate was too optimistic as it seems that many brightness determinations of M. Wolf were about 2 magnitudes too bright.

Figure 2 shows the observations I made of this star over a period of more than two weeks. During this period the star dropped more than one magnitude in brightness. Figure 2 also clearly shows individual nightly brightness variations of about 0.3 magnitude.

Figure 3 shows the time series observation made during the first night. Clearly a superhump of 0.3 magnitude is visible. The magnitude of the superhumps reduced to about 0.15 magnitude after a couple of days.

Based on the analysis by the Kyoto team, there have been distinct stages in the evolution of superhumps in SV Ari. The mean period before August 4 was 0.05574(18) day which since then shortened to 0.05519(5) day. Also, later data showed that SV Ari was gradually declining (~ 0.05 mag./day). This seemed very slow for an ordinary SU UMa type dwarf nova. Thus, this object might be a WZ Sge-type dwarf nova. This information is based on e-mail exchanges via VSNET. Towards the end of August 2011, SV Ari had dimmed towards magnitude 18.

4. BW Sculptoris

Another example of an intensively followed star is BW Sculptoris, which went into its first-ever observed outburst on 2011 October 21. BW Scl is also a cataclysmic variable star. On the same day the *AAVSO Special Notice #261* (AAVSO 2011a) was published mentioning the outburst of BW Scl. It was visually observed by M. Linnolt on October 21.3146 at a magnitude of 9.6 (visual). The outburst was confirmed by A. Plummer at magnitude 9.4 (visual). The star has conflicting classifications in the literature and is probably a WZ Sge-type dwarf nova. On October 25, the *AAVSO Alert Notice 449* (AAVSO 2011b) was issued concerning this outburst.

I had already been following this star in its pre-outburst phase. However, I missed the outburst, as I thought the star was not doing much, and ceased observing it on October 14—just a week before the outburst took place. Of course, I restarted observations immediately after the news was spread and followed the star over a period of 2.5 months. Figure 4 shows the development of the brightness over the full observing period.

After a few days nice superhumps of about 0.25 magnitude developed, as can be seen in Figure 5. After a week into the outburst the early superhump

period was determined to be 0.054308(3) day by Kato (2011b). After a rapid declining phase from magnitude 11.7 to about magnitude 14, nice superhumps of 0.3 magnitude developed, beginning at about JD 2455877.

5. VW Hydri

At the request of professional astronomers from South Africa (P. Woudt (2011)), I began observations of VW Hyi just as the star went into superoutburst, although that was a surprise to the pros, as the superoutburst was not expected yet. My observations triggered satellite observations of the star.

VW Hyi is a popular cataclysmic variable in the Southern sky. Many studies have been performed on this star; see, for example, AAVSO (2010). During quiescence the star is at magnitude 14.4, Normal outbursts happen on average every 27.3 days and last about 1.4 days. The superoutburst happens on average every 179 days and lasts for about 12.6 days. Figure 6 shows impressively this behavior of VW Hyi with one superoutburst and two normal outbursts.

The star develops strong superhumps during its outburst as can be seen in Figure 7. The variation of those humps reaches 0.5 magnitude.

6. Example of an RR Lyr star, V1820 Ori

This type of variable is named after the prototype, the variable star RR Lyrae in the constellation Lyra. RR Lyr stars are pulsating horizontal branch stars with a mass of about one-half of our Sun's. Their period is short, typically less than one day.

My interest in observing RR Lyr stars is, on the one hand, due to the short period of those stars—within one night you can see quite a change in brightness. On the other hand, the stars also show some brightness modulations, known as the Blazhko effect. Back in 1907 S. Blazhko observed this effect for the first time in the star RW Dra (see Smith 2004). The Blazhko effect is not well-understood and needs further observational campaigns. Recently due to the Kepler and CoRoT satellite missions, more insight into this phenomenon has been gained as the satellites can, of course, observe the stars continuously, which is impossible for Earth-bound observations. Nevertheless, observations from Earth are also very valuable, as can be seen in many publications on this subject in the astronomical literature. Figure 8 shows the phase diagram of the RR Lyr star V1820 Ori, which has been observed from Chile over a full season (more than 3 months). It is obvious from the figure that the light curve is not regular, the maximum brightness is changing over more than 0.5 magnitude, and the moment of maximum time is changing. So a rather complex light curve is the result. Presently the data are under analysis, and I intend to publish the results.

7. Conclusion

The remote observatory under pristine skies in the Atacama Desert of Chile opens up great possibilities to observe variable stars. Intensive follow-up observations over many days, weeks, or even months are possible due to the stable weather conditions. The given examples show impressively what is possible. I welcome collaborations in order to contribute to scientific research of common interest.

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Figure 1. Photo of the remote telescope installation in Chile.

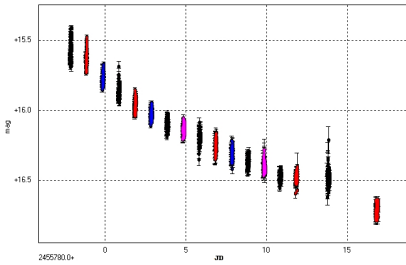


Figure 2. Light curve of the observations of SV Ari over a period of more than two weeks. Different colors represent observations during different nights.

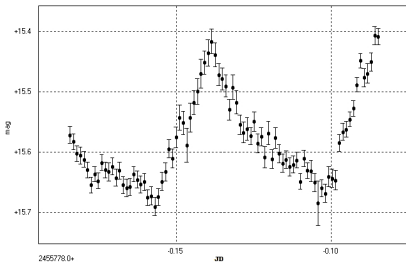


Figure 3. Light curve of the observations of SV Ari showing a superhump during one night of observation.

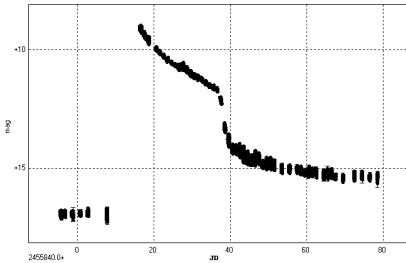


Figure 4. Light curve of the observations of BW Scl over a period of nearly three month.

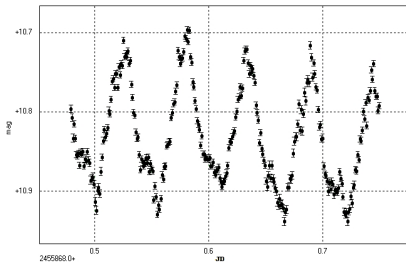


Figure 5. Light curve of the observations of BW Scl showing several superhumps during one night of observation.

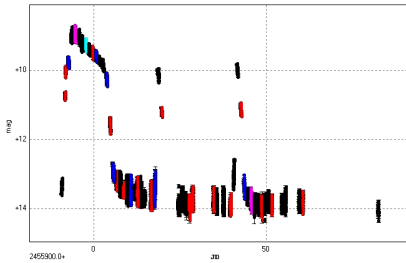


Figure 6. Observations of VW Hyi during superoutburst and normal outburst. Different colors represent observations during different nights.

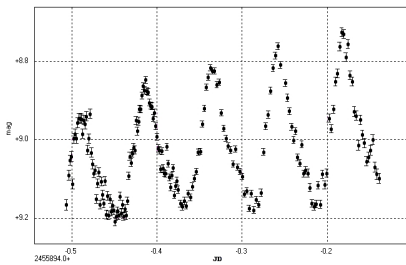


Figure 7. Observations of VW Hyi during one night at the top of the superoutburst clearly showing strong superhumps.

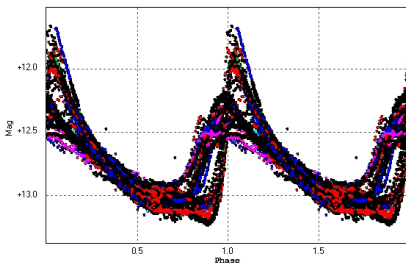


Figure 8. Phase diagram of the observations of V1820 Ori over a period of nearly three months. Different colors represent observations during different nights.